Interconversion of the National Institute of Health Stroke Scale and Scandinavian Stroke Scale in acute stroke

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Conflicts of interest

We declare no conflicts of interest.

ABSTRACT

Introduction: The National Institutes of Health Stroke Scale (NIHSS) and Scandinavian Stroke Scale (SSS) are both validated measures of neurological impairment and have been used in many acute stroke trials. Methods for interconverting SSS and NIHSS are needed.

Methods: Conversion equations were developed using linear regression (both unadjusted, and adjusted for age and sex) using a random 50% of the data at both baseline and 90 days. The remaining 50% of data were used to test the accuracy of the models produced.

Results: Data from 5 acute stroke trials (2,004 patients) were included. Fitted models at baseline were NIHSS=25.68–0.43xSSS (R^2=0.57, prediction error (PE) -0.2, p=0.20), and SSS=50.37–1.63xNIHSS (R^2=0.59, PE 0.2, p=0.35). 90 day models were NIHSS=22.99-0.39xSSS (R^2=0.82, PE -0.3, p=0.001), and SSS=56.68–2.20xNIHSS (R^2=0.80, PE -0.4, p=0.08). Adjustment did not materially improve the R^2 values.

Conclusion: Total scores for NIHSS and SSS may be interconverted with good precision; the mathematical conversion equations may prove useful in clinical practice and in comparison of data from observational studies and randomised trials.

INTRODUCTION

Stroke severity is measured routinely, using an impairment scale, in acute stroke trials. Common scales include the National Institutes of Health Stroke Scale (NIHSS)(1) and Scandinavian Stroke Scale (SSS)(2). Both scales are validated and share common measures of impairment, but differ in their direction of measurement (e.g. no impairment is 0 of 42 in NIHSS and 58 of 58 in the SSS), the weighting they give to individual items, and the inclusion/exclusion of specific measures (e.g. SSS records hand strength, NIHSS measures extinction but not *vice versa*). As a result, it is not possible to derive one score directly from the other. Nevertheless, the scales are highly interdependent so interconversion is possible and meaningful. In the past, conversion schemes have been developed for various stroke impairment scales;(3,4) a scheme for converting NIHSS and SSS was recently published based on just 144 patients.(5)

The aim of the study was to develop reliable mathematical models for interconversion using a large dataset from the Virtual International Stroke Trials Archive (VISTA).(6)

METHODS

Data

Data from five acute stroke trials included in VISTA (6), where both NIHSS and SSS had been recorded at baseline and day 90, were included. Information on age, sex, side of stroke, t-PA use, stroke type, and functional outcome at 90 days (modified Rankin Scale and Barthel Index) were also provided.

Statistical methods

Conversion equations were developed using linear regression (both unadjusted, and adjusted for age and sex) using 50% of the data selected at random; the remaining 50% of data were used to test the accuracy of the models produced. The trials all excluded patients with mild impairment (e.g. NIHSS<3, SSS>50) and used exclusion criteria that will have confounded impairment, e.g. time to treatment, age and sex. In addition, we excluded data from the severe extreme of the NIHSS, where data were sparse (NIHSS>37); no such exclusion was needed for the SSS as data was well populated along the scale. The difference between the actual and predicted values were calculated for both equations and the t-test was used to see if this difference was significantly different to zero.(4) The test data set was also used to compare the baseline NIHSS to SSS model with one produced in a previous paper.(5) All statistical analyses were carried out using SAS (version 9) and statistical significance relates to $p<0.05$.

RESULTS

Data from five completed acute stroke trials were included, with a mean time to treatment of 7 hours. 2,004 patients had baseline data collected on both the SSS and NIHSS. 1,628 patients had day 90 data available for both scales, and 1,505 patients had both baseline and day 90 data. The patients included are reasonably representative of stroke trial patients, with a mean age of 66 (standard deviation 11.8) and slightly more males (57%) than females.

Conversion models

The conversion models are shown in table 1. The day 90 models had greater adjusted R^2 values than the baseline models (R^2 0.57 to 0.60 at baseline and 0.80 to 0.82 at day 90) and therefore have a better fit and explain more of the variation. Further, adjusting for age and sex did not substantially change the fit of the models. When comparing the actual values to the predicted values, all models, apart from the NIHSS to SSS conversion at day 90, showed a non-significant difference between the actual data and that produced by the models. The NIHSS to SSS day 90 model tended to over predict the NIHSS by a mean of 0.29 points (0.73 for the adjusted model).

When comparing the baseline NIHSS->SSS conversion model with the model produced by Ali *et al* (SSS=50-2*NIHSS)(5), the conversion model given here (SSS=50.37-1.63*NIHSS) more closely predicted the actual SSS score - mean difference between the actual and predicted values 5.02 in the model by Ali *et al* and -0.29 in the model produced here.

DISCUSSION

The results show that NIHSS and SSS can be derived from each other in both directions with reasonable to good degrees of reliability. Mathematical models using data measured at baseline had an acceptable level of fit between the actual and predictive values. In particular, the variation was always less than one point on either scale. The models produced with data collected at 90 days post randomisation had a higher goodness of fit, although converting SSS to NIHSS predicted higher values of NIHSS than observed. Taking account of age and sex did not change the results or improve the goodness of fit of the models.

Several comments can be made about this study. First, although the five included trials had varying inclusion-exclusion criteria, patients with mild or very severe impairment were excluded, so data at the extremes of the scales were sparse. Second, the scales work in different directions, include different weightings for some common items, and contain some items not present in the other. Although these differences could affect the validity of the developed conversion models, the data come from five rigorously designed and conducted trials. Furthermore, the developed mathematical models are based on the largest dataset and facilitate bidirectional translation of the two scales.(6) Last, the formulae for interconverting SSS and NIHSS are only given for measurements at baseline and 90 days, since these are the time points for the source data. Nevertheless, these time points reflect the most common used in clinical trials and therefore occur when interconversion of stroke scales may be most needed.

This work may be useful to researchers in several respects. The NIHSS is routinely used in clinical practice and trials in the US, whilst European countries tend to use either scale. Hence, clinicians may wish to interconvert the scales to facilitate

comparisons between countries. The models may also be useful in guidelines and meta-analyses, allowing data from different observational studies and randomised trials to be integrated.

In summary, the NIHSS and the SSS may be interconverted in both directions using mathematical equations with acceptable fit and accuracy.

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TABLE 1

Mathematical conversion models

Time point	Conversion	Unadjusted		Adjusted	
		Model	Adj R^2	Model	Adj R^2
Baseline	SSS<-NIHSS	SSS=50.37-1.63*NIHSS	0.59	SSS=47.33-(1.62*NIHSS)+(0.03*AGE)+(1.29*MALE)	0.60
Day 90	SSS<-NIHSS	SSS=56.68-2.20*NIHSS	0.80	SSS=62.26-(2.18*NIHSS)-(0.10*AGE)+(0.92*MALE)	0.80
Baseline	NIHSS<-SSS	NIHSS=25.68-0.43*SSS	0.57	NIHSS=22.45-(0.43*SSS)+(0.04*AGE)+(0.29*MALE)	0.58
Day 90	NIHSS<-SSS	NIHSS=22.99-0.39*SSS	0.82	NIHSS=24.59-(0.39*SSS)-(0.02*AGE)+(0.28*MALE)	0.82